A Freshwater Field Study: Abiotic Factors and Macroinvertebrate Bioassessment

Organizing Topic Ecology

Overview Students study the abiotic and biotic factors that impact a freshwater environment. They make and interpret scientific measurements, using probeware or alternate tests, and determine the limitations of freshwater organisms, given the abiotic factors of the freshwater environment. They learn how to predict the quality of a water environment by knowing the facts about either the water quality or the living organisms.

Related Standards of Learning BIO.1a, d, h; BIO.5 b, c; BIO.7a; BIO.9a, b, c, d, e

Objectives

The students will
- define *abiotic factors,* and explain how they affect the biodiversity of a freshwater ecosystem;
- for typical watershed environments, contrast organisms found when water quality is good (optimum conditions) and when water quality is poor;
- use water test kits in measuring various abiotic factors, and record water quality for each factor;
- collect living organisms, classify them, and use data to make inferences about water quality.

Materials needed

For Team 1:
- Temperature probe (ºC) or thermometer (ºC)
- pH probe or pH strips (available at most pet supply or drug stores; must have range of 4–11)
- Dissolved oxygen probe (mg/l) or dissolved oxygen test kit (see http://www.hach.com)
- Conductivity probe (mg/l) or hydrometer
- Turbidity probe (measured in NTU) or Secchi disk
- Flow-rate probe (cfs) or flotation measurement device
- Student data sheet

For Team 2:
- Onion bags, leaves, rocks
- Net with a straight edge
- Kick seine (instructions for making at http://www.people.virginia.edu/~sos-iwla/Stream-Study/Methods/KickSeine.HTML how to build a kick seine)
- White plastic sheet, wading boots, blankets
- Buckets with handles
- Small nets, forceps, pipettes
- Magnifying lenses
- Plastic rulers
- Resources for identifying macroinvertebrates
- Student data sheet

Instructional activity

Content/Teacher Notes

Scientists called “limnologists” study freshwater environments to learn more about water quality and trends in natural succession and/or human influences on that environment. The quality of the water

impacts the kinds and quantity of organisms that can live in it. Each type of organism has a "preference" or a "limit" in regard to the quality of its freshwater environment. Water quality is determined by measuring and analyzing the **abiotic** (nonliving) factors. Some of these factors are pH, temperature, dissolved oxygen, total dissolved solids, turbidity, and stream flow. Various equipment can be used to make these measurements, ranging from simple wet chemistry tests to probeware.

The **biotic** environment is analyzed using a **bioassessment** — i.e., assessment of a sampling of living organisms in a water environment. Bioassessments are particularly helpful for limnologists trying to determine the health of a river or stream. A bioassessment using macroinvertebrates is a procedure that uses inexpensive equipment and is scientifically valid if done correctly. A macroinvertebrate bioassessment can provide a benchmark to which other water may be compared and can be used to monitor trends. It also gives an indication of the recent history of the water environment.

Sampling both abiotic and biotic factors may give an indication of the current and past quality of a water environment. To gather the best and most usable data, the Environmental Protection Agency (EPA) recommends that sampling be conducted in ways that minimize year-to-year variability. Limnologists tend to sample during one week of the same season(s) each year.

This field study will sample abiotic factors, using probeware or similar field equipment, and will involve a bioassessment, using macroinvertebrates. Before starting the study, enlist the expertise of local natural resource professionals. (See "Suggested Web sites with teaching tips" and "Suggested Web sites with information about local natural resource personnel" under Resources at the end of this lesson.) They will help you identify a suitable site for testing at or near your school. Water studies can be conducted near almost any school — rural, urban, or suburban. An ideal site would be a stream or river on or close to school property. Drainage ditches and holding ponds can work well, too. If the site is off school property, seek permission from the owner. Collection sites should be safe and easily accessible.

If a water site is not available close to school property, a classroom aquarium can be used. A freshwater aquarium can be stocked using organisms from area ponds, lakes, or rivers. Minimally, the aquarium will need an oxygen source (aerator), thermometer, and pH indicator.

During the collection and sampling process, ask students how the site may have looked 10 years ago, 50 years ago, 100 years ago. Then ask what activities influence the site now and how the site may look 10 years from now, 50 years, 100 years. Tell them that they have just described **succession.**

Introduction

1. At least one week prior to the field day, choose a water site that does not have slippery banks, is not deep, and does not have swift currents. Draw a map of the site, and indicate three sampling areas on the map.
2. In order to capture as many macroinvertebrates as possible at the sampling site, submerge three onion bags filled with leaves and rocks (for weight) in the water at the three sampling areas so they can sit in the water for at least a week before the field day.

Procedure

In the classroom before sampling:

1. On the day before the field day, review all safety procedures with the students, and emphasize that they must wear warm, waterproof clothes when working in the stream the next day. Spare socks and shoes should be available in case shoes get wet, and a blanket should be available in case someone falls in.
2. Divide the students into two teams: Team 1 will study abiotic factors and decide which tests will be performed in the field and which tests will be done in the lab. Team 2 will conduct the

bioassessment. Consider having the students conduct each of their assigned tests in the lab for practice before venturing to the water site.

3. Distribute maps showing the three sampling areas at the site.

At the sampling site:

4. Have Team 1 use probeware or alternative sampling equipment to take measurements and record abiotic data for the three sampling areas. If using alternative sampling equipment, additional containers may be needed to bring water back to classroom to conduct testing.
5. Have Team 2 gather the macroinvertebrates that may have collected in the submerged onion bags. Have them pick through the leaves and other debris for macroinvertebrates and place all the organisms they find in a bucket partially filled with clear water. Then, have them use a net to dredge one square meter of the bottom of the water environment in each of the three sampling areas to gather additional macroinvertebrates and place these in the bucket also.

In the classroom after sampling:

6. Have Team 1 calculate and record on the student data sheet abiotic data averages for all three water samples. For seasonal studies, have them plot measurements on a graph and determine the water quality, using the scale on the data sheet.
7. Assist Team 2 in identifying all the organisms they collected (see list on the data sheet with spaces to list additional organisms). Then, have Team 2 separate the organisms into separate containers according to tolerance and determine the water quality, using the scale on the data sheet.

Observations and Conclusions

1. Have each team analyze their results and answer the discussion questions. Post the answers.
2. Hold a class discussion, using the following questions:
   - What was the weather on the field day?
   - Did the water have an odor? If so, describe it.
   - Were the results for the abiotic factors and bioassessment the same or different? Why?
   - Predict the history of the sampling site, based on the test results.
   - Describe the sampling site and the terrestrial environment that drains into the freshwater environment at the site.
   - Describe the watershed area into which the sampling site drains.
   - What are some external influences on the sampling site? Are there any future influences, such as construction, that may influence the sampling site? What changes would you expect in the abiotic factors if these future influences come about? What changes would you expect in the bioassessment?
3. Have students write a paragraph connecting the sampling site and the results. Instruct them to include the following words: *bioassessment, abiotic factors, weather, history, succession, biodiversity, limnology, macroinvertebrates,* and *equipment.*

Sample assessment

- Have students solve a teacher-created crossword puzzle that uses the following words:

bioassessment	turbidity	bioindicators	arthropods
succession	temperature	larvae	worms
abiotic	limnology	crustacean	water quality
dissolved oxygen	macroinvertebrates	mollusks	

Follow-up/extension

- Using the same field equipment, have the students do one or more of the following:
  - Switch teams and perform the same tests
  - Conduct the same water study at different times of the year
  - Conduct the same water study in different locations
- Have students calculate the Dissolved Oxygen Percent Saturation, using the data found at http://k12science.ati.stevens-tech.edu/curriculum/dipproj2/en/fieldbook/saturation.shtml.

Resources

- *Chesapeake Bay Foundation: Save the Bay.* http://www.cbf.org.
- *Healthy Water, Healthy People.* The Watercourse, International Project WET, Montana State University. http://www.healthywater.org.
- *Key to Stream Invertebrates.* http://imc.lisd.k12.mi.us/msc1/invert/key.html.
- *Take a Dip: The Water in Our Lives.* "Data Collection Student Worksheet." http://k12science.ati.stevens-tech.edu/curriculum/dipproj2/en/docs/activity3worksheet.shtml.
- *Virginia Naturally: Linking Virginians to the Environment.* http://www.vanaturally.com.

Suggested Web sites with teaching tips:

- *HACH.* http://www.hach.com. Complete listing of water test kits.
- *PASCO: Innovative Solutions for Science Learning.* http://www.pasco.com. Source for freshwater probeware and other sensors.
- *Secchi Disk.* http://sebagolakeassc.org/secchi.htm. A site with good graphics on Secchi disks and how they work.
- *Vernier: Measure, Analyze, Learn.* http://www.vernier.com. Refer to "Water Quality Testing" from Vernier for explanation of how probes work in testing water. Included in this text is an explanation of different kinds of tests, who uses them, and what they indicate.

Suggested Web sites with background information:

- "A Field Manual for Water Quality Monitoring." http://www.swrcb.ca.gov/nps/docs/cwtguidance/2311sop.pdf. Contains a list of chemicals and equipment needed to set up a water-quality test; good reference for an explanation of the water quality index, a standardized test using nine weighted indicators to give a numerical indication of water quality.
- *Dissolved Oxygen Percent Saturation.* http://k12science.ati.stevens-tech.edu/curriculum/dipproj2/en/fieldbook/saturation.shtml. Explains the connection between dissolved oxygen and temperature.
- *The Secchi disk — What is it?* http://www.mlswa.org/secchi.htm. Answers: What is a Secchi disk? How does it measure turbidity? Why and who developed it? Gives some background information about a very old form of measurement and why it is still used.

Suggested Web sites with information about local natural resource personnel:

- *Chesapeake Bay Foundation: Save the Bay.* http://www.cbf.org.
- *Virginia Naturally: Linking Virginians to the Environment.* http://www.vanaturally.com.

A Freshwater Field Study: Abiotic Factors
Student Data Sheet for Team 1

Name: _____ **Date:** _____

	Data	Quality Criteria		Ranking
Temperature (ºC)		**<20ºC: optimal for all organisms** **20–25ºC: optimal for most organisms** **25–32ºC: too warm for some organisms** **>32ºC: too hot for most organisms**	**5** **3** **1** **0**	
Dissolved oxygen (mg/L)		**8.0–12: optimal** **4.0–7.9: adequate** **<2: poor**	**5** **3** **0**	
pH		**0–3.9: very acidic** **4.0–5.9: acidic** **6.0–6.4: slightly acid** **6.5–7.5: optimal** **7.5–8.0: slightly basic** **8.1–9.0: basic** **9.1–14: very basic**	**0** **1** **3** **5** **3** **1** **0**	
Turbidity (cm) **(Secchi disk reading)**		**>100** **99–30** **29–15** **14–0**	**5** **3** **1** **0**	
Total dissolved solids (mg/L)		**No ranking.** **Range: 50–250 mg/l**		*****
Stream flow (optional test)		**No ranking**		*****
			TOTAL	

Water Quality Scale

16–20	Very healthy for most organisms
12–15	Suitable for most organisms
8–12	Unsuitable for some organisms
4–7	Unsuitable for most organisms
0–3	Unsuitable and dangerous

Conclusions

1. Which tests indicated healthy water for organisms?

   _____

2. Which tests indicated unhealthy water for organisms?

   _____

3. Based on the rankings in the Water Quality Scale, what is the water quality of the sampling site?

   _____

4. Based on the results, would the **biodiversity** (number and variety of organisms) in this area be high or low? _____
5. What would be the influence of the season of the year on the results?

   _____

A Freshwater Field Study: Macroinvertebrate Bioassessment Student Data Sheet for Team 2

Name: _____ **Date:** _____

A. Sensitive to Environmental Stresses	No.	B. Somewhat Sensitive to Environmental Stresses	No.	C. Tolerant of Environmental Stresses	No.
Stonefly larvae		Dragonfly larvae		Midgefly larvae	
Mayfly larvae		Damselfly larvae		Blackfly larvae	
Caddisfly larvae		Alderfly larvae		Aquatic worms	
Dobsonflies		Cranefly larvae		Leeches	
Riffle Beetles (adult)		Riffle Beetle larvae		Snails	
Water Penny larvae		Clams or mussels			
Planaria		Crayfish			
		Scuds			
		Sowbugs			
TOTAL NO.		**TOTAL NO.**		**TOTAL NO.**	
	x 4		**x 3**		**x 1**
TOTAL POINTS		**TOTAL POINTS**		**TOTAL POINTS**	
GRAND TOTAL: A + B + C =					

Water Quality Scale

>23	Potentially excellent water quality
17–22	Potentially good water quality
11–16	Potentially fair water quality
<10	Potentially poor water quality

Conclusions

1. Which category had the most macroinvertebrates? _____

2. Which category had the fewest macroinvertebrates? _____

3. Based on the rankings in the Water Quality Scale, what is the water quality of the sampling site?

   _____

4. Why are macroinvertebrates used for bioassessments?

   _____

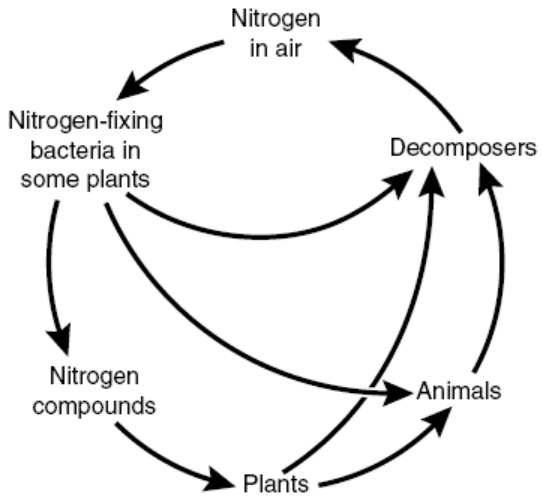
5. What would be the influence of the season of the year on the results?

   _____

Sample Released SOL Test Items

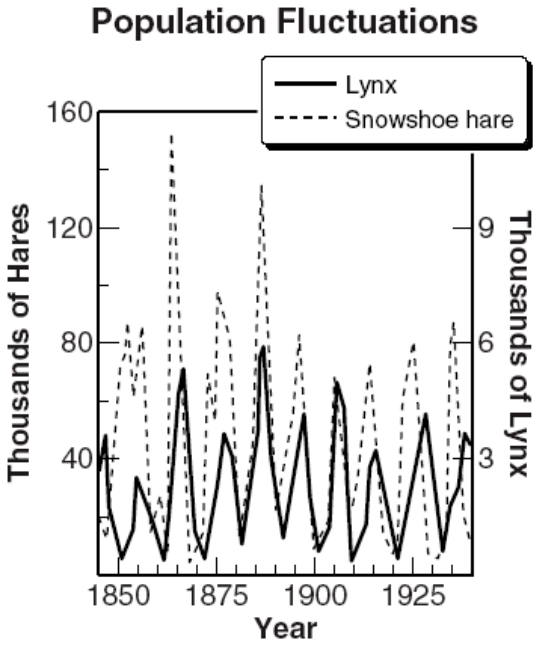
Organisms reproduce following several patterns. Some organisms produce few offspring and provide parental care. Other organisms produce many offspring but provide little or no parental care. Which of the following organisms has the greatest risk of losing a population due to the death of only a few individuals?

F Bacteria
G Flies
H Elephants
J Rats



The diagram shows a simplified nitrogen cycle. Which process is responsible for returning nitrogen to the air?

F Excretion
G Decomposition
H Photosynthesis
J Nitrification



This graph shows the sizes of lynx and hare populations between the years of 1845 and 1940. If a predator of the lynx enters the food chain, you might expect the number of —

A lynx and hares to become equal
B lynx to increase
C hares to increase
D hares and lynx to decrease

One way to increase the number of organisms in an endangered species is to let the few remaining individuals of that species breed. However, this breeding may also lead to species extinction because inbreeding over a short period of time may —

F reduce genetic diversity
G increase beneficial mutations
H produce a different species
J increase fertility